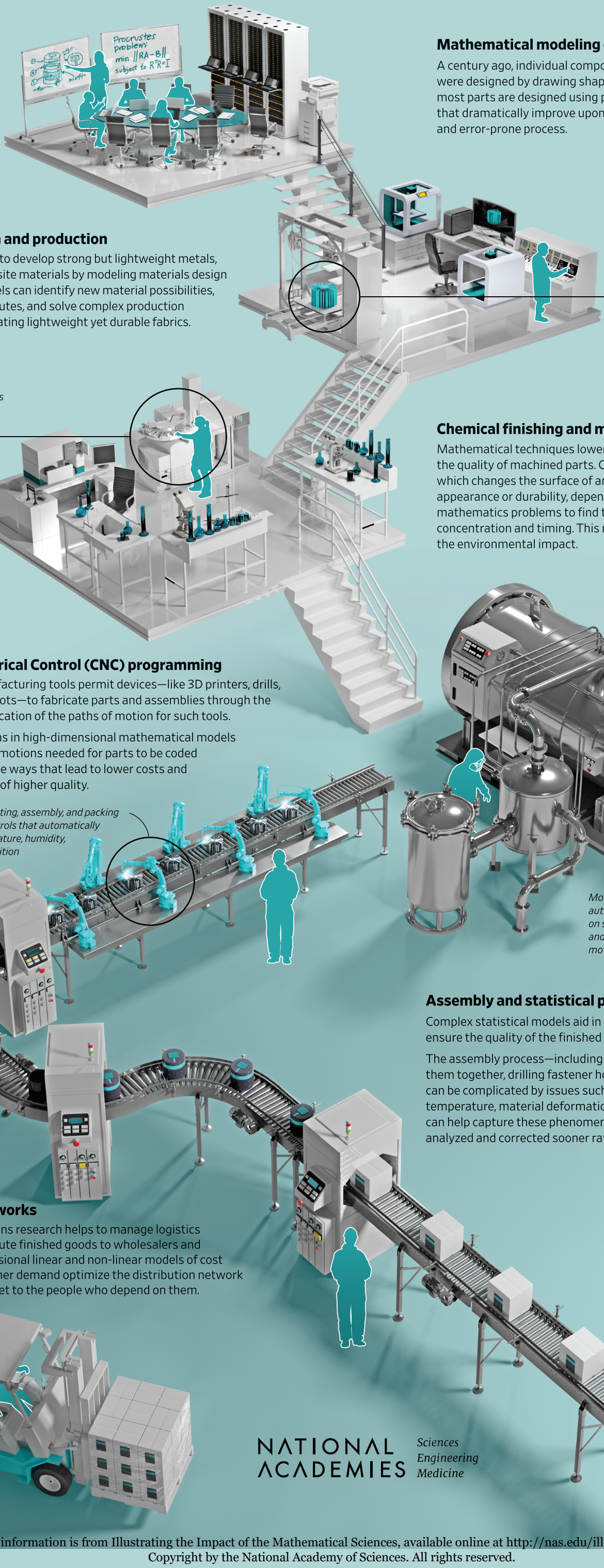
Manufacturing with Mathematics

From shoes to computers, mathematics helps manufacturers make things faster, cheaper, and better.



Mathematical modeling of parts and assemblies

A century ago, individual components of manufactured goods were designed by drawing shapes and figures on paper. Now, most parts are designed using precise mathematical models that dramatically improve upon the former labor-intensive and error-prone process.

Materials design and production

Mathematics is used to develop strong but lightweight metals, ceramics, and composite materials by modeling materials design and production. Models can identify new material possibilities, explore processing routes, and solve complex production problems such as creating lightweight yet durable fabrics.

3D printing relies on detailed mathematical models of part size, shape, and material composition.

Mathematical simulations bring costs down and get new products to the market faster.

Chemical finishing and milling

Mathematical techniques lower the cost and improve the quality of machined parts. Chemical finishing, which changes the surface of an object to enhance its appearance or durability, depends on solving sophisticated mathematics problems to find the correct chemical concentration and timing. This reduces waste and lessens the environmental impact.

Computer Numerical Control (CNC) programming

CNC-equipped manufacturing tools permit devices—like 3D printers, drills, cutters, mills, and robots—to fabricate parts and assemblies through the mathematical specification of the paths of motion for such tools.

Specifying these paths in high-dimensional mathematical models permits the complex motions needed for parts to be coded in repeatable, accurate ways that lead to lower costs and manufactured goods of higher quality.

Robotic arms—used in sorting, assembly, and packing—have mathematical controls that automatically adjust to ambient temperature, humidity, and even the current condition of the machines.

Models for making composite parts in an autoclave—a giant pressure cooker—depend on simultaneously solving the heat equation and a dynamical system that describes movement of particles over time.

Assembly and statistical process control

Complex statistical models aid in product assembly and help to ensure the quality of the finished result.

The assembly process—including placing subparts, securing them together, drilling fastener holes, and installing fasteners—can be complicated by issues such as measurement error, temperature, material deformations, and distortions. Modeling can help capture these phenomena and enable errors to be analyzed and corrected sooner rather than later.

Distribution networks

A field called operations research helps to manage logistics and efficiently distribute finished goods to wholesalers and retailers. High-dimensional linear and non-linear models of cost structure and consumer demand optimize the distribution network to make sure goods get to the people who depend on them.

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